Strange and multi-strange baryon measurement in $Au + Au$ collisions at $11.6A(GeV/c)$ with the silicon drift detector array from the AGS experiment E896

G. Lo Curto[a], S. Albergo[e], R. Bellwied[l], M. Bennett[j], D. Boemi[e], B. Bonner[i], Z. Caccia[e], H. Caines[a], W. Christie[b], S. Costa[e], H. Crawford[j], M. Cronqvist[j], R. Debbe[b], J. Engelage[j], I. Flores[j], L. Greiner[j], T. Hallman[b], G. Hoffman[k], H. Huang[c], T.J. Humanic[a], G. Igo[c], A. Insolia[e], P. Jensen[k], E. Judd[j], K. Kainz[i], M. Kaplan[d], S. Kelly[c], I. Kotov[a], G. Kunde[m], P. Lindstrom[g], T. Ljubicic[b], W. Llope[i], R. Longacre[b], D. Lynn[b], L. Madansky[f], N. Mahzeh[l], Z. Milosevich[d], J. Mitchell[b], J. Mitchell[h], S. Nehmeh[l], C. Nociforo[e], S. Paganis[k], S.U. Pandey[l], R. Potenza[e], E. Platner[i], P. Riley[k], D. Russ[d], G. Russo[e], A. Saulys[b], J. Schambach[k], J. Sheen[l], C. Stokley[i], E. Sugarbaker[a], J. Takahashi[l], J. Tang[k], S. Trentalange[c], A. Tricomi[e], C. Tull[g], C. Tuve[e], J. Whitfield[d], K. Wilson[l]

The E896 Collaboration

[a]Ohio State University (USA); [b]Brookhaven National Laboratory (USA); [c]University of California, Los Angeles (USA); [d]Carnegie Mellon University (USA); [e]University of Catania (Italy); [f]Johns Hopkins University (USA); [g]Lawrence Berkeley Laboratory (USA); [h]NASA, Goddard Space Flight Center (USA); [i]Rice University (USA); [j]Space Sciences Laboratory, Lawrence Berkley Laboratory (USA); [k]University of Texas, Austin (USA); [l]Wayne State University (USA); [m]Yale University (USA)

The main purpose of experiment E896 is to study the production of strange hadrons, in particular the predicted six-quark di-baryon, the H_0. The placement of the silicon drift detector array (SDDA) close to the target in a 6.2T magnetic field is optimized for the reconstruction of a short lived H_0 as well as of strange baryons (Λ, $\overline{\Lambda}$, Ξ^-).

Simulations show that with the present data sample a detailed study of the Λ and Ξ^- yields and distributions may be performed and a clear $\overline{\Lambda}$ signal might be detected.

Simulations as well as a preliminary analysis of the SDDA data will be presented.

1. Introduction

The measurement of strange baryons as a signature for the existence of a quark gluon plasma (QGP) has been predicted long ago [1].

Several SPS experiments ([2],[3],[4]) have presented data that, according to some models ([5]), are compatible with the production of QGP even in the absence of chemical equilibration. It would be of extreme interest to build an excitation function for the strangeness signature (as well as for any other QGP signature), from AGS to SPS. In this regard high statistics Λ, $\overline{\Lambda}$ and Ξ measurements at the AGS are needed in order to measure with small uncertainty dN/dy as well as m_T distributions. These would then be compared with those measured at the SPS and with predictions from models.

The AGS experiment E896, whose main objective is the search of the H^0 di-baryon using the $11.6 \cdot AGeV/c$ AGS gold beam colliding on a gold target, is well suited for strange and multi-strange baryon measurements. In particular, the silicon drift detector array (SDDA) is an excellent tool for the study of such particles in the mid-rapidity region.

2. Apparatus

The experiment E896 has already been described elsewhere ([6]). This section will focus on the Silicon Drift Detector Array (SDDA), an array of 15 planes of silicon drift detectors placed in a $6.2T$ magnetic field at approximately $10cm$ from the target. The drift field is parallel (or antiparallel) to the main component of the magnetic field which is vertical and directed upward. Each wafer is $300\mu m$ thick, has a surface of $6.3 \times 6.3cm^2$ and is divided into two subsections drifting electrons in two opposite directions (see figure 2). The maximum drift distance is $3cm$. The wafers used in the SDDA are prototypes of the silicon vertex tracking (SVT) system [7] of the STAR experiment [8]. Neutron

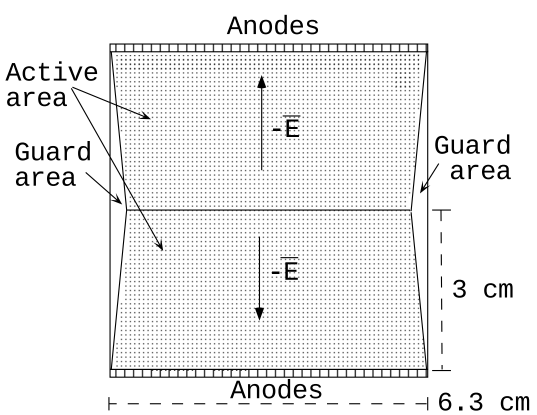

Figure 1. A silicon drift detector wafer.

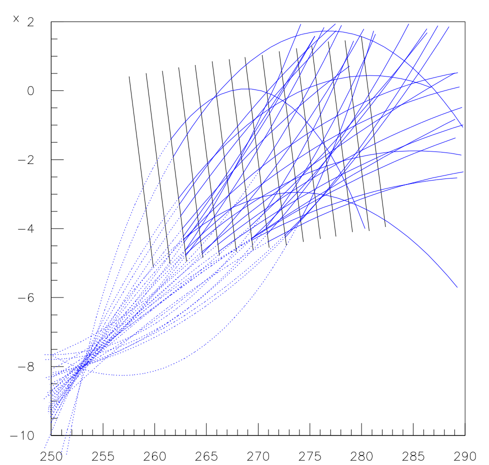

Figure 2. Tracks in the SDDA.

transmutation doped (NTD), high resistivity N-type Silicon ($\rho = 3.5k\Omega/cm$) was used as starting material. On each wafer side terminating the respective drift field, 240 readout anodes were implanted with a $250\mu m$ spacing. The majority of minimum ionizing particles create a signal on more than one anode, allowing for charge sharing between anodes and a better position resolution. By measuring the position of a fixed laser input during the entire data taking period an approximate position resolution of $25\mu m$ in the anode direction was measured. At a drift field intensity of $500V/cm$ the drift velocity is about $5.3\mu m/ns$ in the presence of a $6.2T$ magnetic field. The effects of strong magnetic fields on silicon drift detectors have been carefully studied in the past ([9]).The main effect is an induced resistance, denoted magneto-resistance, which effectively slows the electron drift. The drift velocity is also dependent on the surface temperature of the wafer, in the form:

$v_d \propto T^{-2.5}$ (a 1 ^oC change in temperature gives $\approx 1\%$ variation in drift velocity at room temperature). Therefore careful temperature calibrations must be performed in order to obtain the best position resolution achievable.

The dimension of the "pixel" in the drift direction is about $300\mu m$ and is defined by the readout frequency ($16.7MHz$). The position resolution in the drift direction has yet to be optimized for the particular environment the SDDA was operating in during the E896 data taking, but data from the bench show that a resolution of the order of $20\mu m$ in the drift direction is achievable. Minimum ionizing particles leave a signal with a minimum pulse height of about $50mV$ which has to be compared with the average noise of $5mV$. However it has to be considered that the measured pulse height, for a given deposited energy, is a function of the drift distance, given that the charge of the electron cloud is conserved during the drift and the cloud spreads due to statistical diffusion of the electrons and Coulomb repulsion. As a consequence the signal to noise ratio and the double track resolution become worse as the drift distance increases. Finally non uniformities of the magnetic field have to be taken into account, they may affect the drift velocity as well as the trajectory of the electrons. Figure 2 shows a typical reconstructed central event projected in the horizontal plane; the interaction vertex is clearly visible (units on the axis are in cm). The wafers are placed at an angle of $22^o52^{'}$ with the beam for the sake of maximizing the coverage in y and p_T for primary particles.

The centrality selection was obtained through a multiplicity detector located $\approx 2cm$ downstream of the SDDA. On average 4% of the most central events passed the centrality requirements, accounting for a maximum impact parameter of $2.6fm$ in the SDDA central data sample, consisting of 680,000 events. An average multiplicity of 60 tracks and an occupancy of 2.3% are measured in central events.

3. Data analysis and preliminary results

Simulations were carried out using the model RQMD 2.2 ([10]) and propagating the events through GEANT ([11]). Figure 3 shows that the detector has a significant acceptance for strange baryons at mid-rapidity over a large transverse momentum range. The predicted yields from the central data set of the SDDA (680,000 events) are: $750 \cdot 10^4$ protons, 250 antiprotons, $200 \cdot 10^3$ Λ, 400 $\overline{\Lambda}$, and 500 Ξ^-. These numbers include branching ratios, geometrical acceptance, and reconstruction efficiencies.

The present status of the data analysis does not implement corrections for the magnetic field non uniformities and temperature variations. The drift velocity has been calibrated in a subset of the detector, and the results shown reflect this partial calibration. The main goal of the SDDA is the reconstruction of the decay of strange particles. In figure 4 a preliminary attempt to reconstruct Λ's from a sample of $10,000$ central events is shown. The background obtained by mixing positive and negative tracks from different events is also plotted (hatched area). A clear peak at the nominal value of the Λ mass is visible above the background.

4. Summary and Conclusions

Simulations show that the SDDA has the capability to reconstruct a large number of strange baryons, resulting in enough statistics to produce rapidity as well as transverse

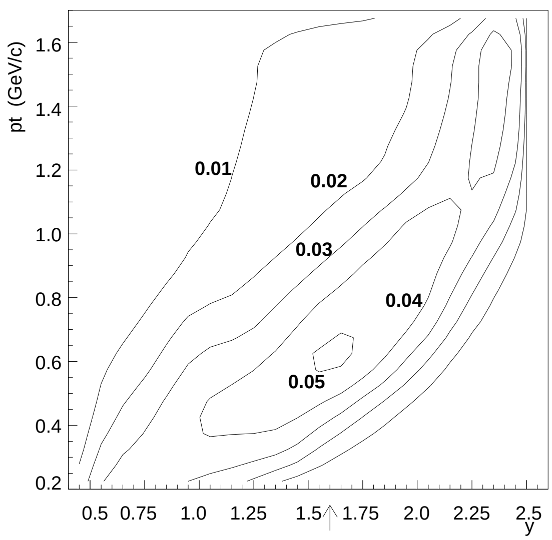

Figure 3. Λ acceptance in the SDDA. The arrow indicates mid-rapidity.

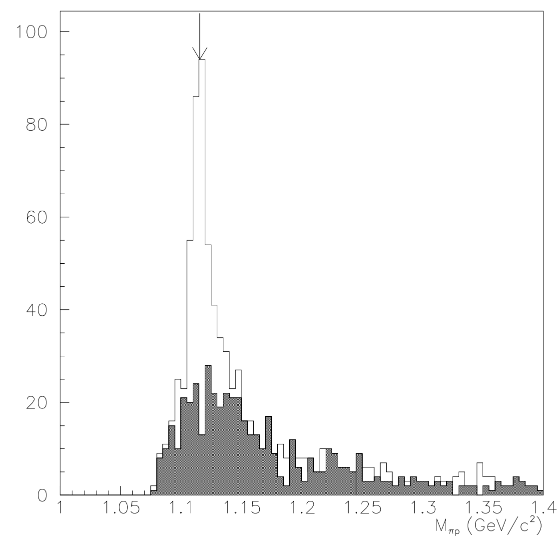

Figure 4. Invariant mass distribution, $p\pi^-$ hypothesis; 10000 events from data. Binning is 5MeV/bin.

mass distributions. The silicon drift detector array performed well during the E896 run and $680,000$ central events were recorded.

The calibration process is complex and special attention is required for the drift velocity calibrations and their dependance on the temperature and the magnetic field.

It has been shown that the SDDA is capable of clearly reconstructing Λ decays. A large effort is presently being spent in completing the calibration and analysis processes.

REFERENCES

1. J. Rafelski and B. Muller, Phys. Rev. Lett. 48 (1982) 1066; 56 (1986) 2334;
2. I. Kralik, for the WA97 Collaboration, Nucl. Phys. A (1998) 115;
3. G.J.Odyniec, for the NA49 Collaboration, J. Phys. G 23 (1997) 1827;
4. S.Abatzis et al. WA85 Collaboration, Phys. Lett. B 347 (1995) 158;
5. J. Rafelski Phys. Rev. C 59 (1999) 947;
6. H. Caines, plenary session report in these proceedings;
7. S.U.Pandey, parallel session report in these proceedings;
8. J. Harris, Nucl. Phys. A566 (1994) 277c;
9. S.U.Pandey et al., NIM A383 (1996) 537;
10. H. Sorge, Nucl. Phys. A630 (1998) 522 and Phys. Rev. C52 (1995) 3291;
11. R.Brun et al., GEANT, CERN program library, W5013.